Electromagnetic Railgun – A "Navy After Next" Game Changer

First Test of Electromagnetic Railgun Facility is a Success

By Lucia Sanchez

The next generation of naval guns was launched Oct. 2, 2006, with the successful test and stand up of an electromagnetic (EM) railgun facility at the Naval Surface Warfare Center Dahlgren Division (NSWCDD) Laboratory.

Under the auspices of the Office of Naval Research (ONR), engineers at the laboratory fired a low energy shot, the first in a series of tests required to bring the facility online.

Using a 90 mm bore launcher with a copper rail and a power plant capable of delivering 8 mega joules (MJ) of muzzle energy, a 2.4 kg projectile was fired at 830 m/s, yielding an energy of 0.8 MJ.

"We are one step closer to the future of naval weaponry with the stand up of this, the largest operational EM facility in the Navy," said ONR program manager for the electromagnetic railgun Dr. Elizabeth D'Andrea.

"The recent advances in science and technology are what has made this technology feasible, as well as the collaboration of scientists and engineers across government agencies, industry and the branches of service," D'Andrea said.

The October low-energy shot was the first in a series of tests required to bring the facility online. According to NSWC Dahlgren Electromagnetic Railgun Office program manager Charles Garnett, all systems performed well during the initial test and full capability operations are anticipated by January 2007.

"With the potential to deliver lethal, hypersonic projectiles at ranges in excess of 200 nautical miles within six minutes, a naval railgun offers a transformational solution for volume fires and time-critical strike," said Commander NSWCDD Capt. Joseph McGettigan.

"Understanding the technical dimensions of ships, ship systems and weapons, allows us to deliver innovative and affordable capability to the nation — as the standup of this facility and the work we do for ONR on this project exemplifies," McGettigan said.

As part of ONR's electromagnetic railgun program, the stored energy, launcher and terminal area will be increased in size to accommodate a 32 MJ muzzle energy gun by fiscal year 2009.

This facility provides the first steps toward the envisioned tactical Navy system of 64 MJ of muzzle energy.

How a Railgun Works

A railgun launcher consists of two parallel conductors, or "rails," bridged by an electrically conductive sliding armature. The gun is fired when a large current pulse is introduced at the end of one rail, flows down the rail, across the armature, and back up the other rail.

This current loop induces a magnetic field, which interacts with the current in the armature, to produce a force proportional to the magnitude of the current. A very large current pulse (millions of amps) will produce a force sufficient to accelerate an integrated armature-sabot-projectile launch package to hypersonic velocity.

Railguns provide a capability for sustained, offensive power projection, complementary to missiles and tactical aircraft.

Railguns may be a cost-effective solution to the Marine Corps Naval Surface Warfare Support future assault requirements for expeditionary maneuver warfare because of their unique capability to simultaneously satisfy three key warfighting objectives: (1) extremely long ranges; (2) short time-of-flight; and (3) high lethality (energy-on-target).

One important distinction between railguns and propellant-based guns is the difference in muzzle velocity. The 5-inch/54 and 5-inch/62 guns of today achieve muzzle velocities of approximately 800 m/s. In contrast, a railgun can accelerate a projectile to hypersonic velocities of 2500 m/s or Mach 7 and greater, enabling more that 200 nautical mile ranges within a six-minute time of flight.

Such high muzzle velocities preclude the need for post-launch rocket-assist to achieve extended ranges. In an indirect fire mode, the projectile flight profile is predominantly exo-atmospheric, reducing the deconfliction problem and potential for Global Positioning System jamming.

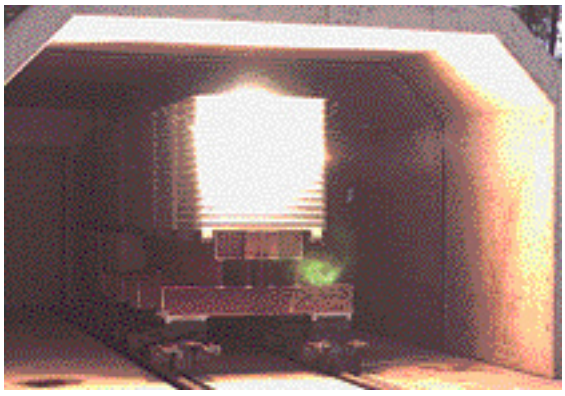
However, railguns could also be used in a direct fire mode against surface targets, with only seconds from time of launch to impact.

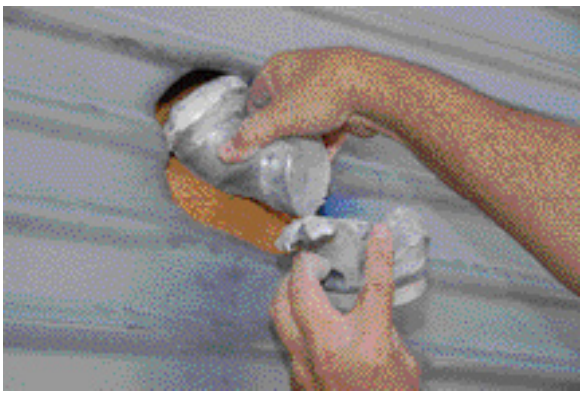
A notional 15 kg railgun flight body arrives on target with a 1500 m/s or Mach 5 terminal velocity, which equates to 17 MJ of available kinetic energy. This is about twice the kinetic energy available from a conventional 5-inch KE warhead from a projectile at half the weight.

Time is Right

Railguns are not a new concept. Railgun research in the United States has been ongoing for more than two decades. In the 1980s, railgun research was conducted under the Strategic Defense Initiative (SDI) in an effort to develop the space-based intercept of intercontinental ballistic missiles.

The electromagnetic rail gun, photo at right shows the strike of a projectile, which produces a flash of light. Post strike is shown at far right. Photos taken Oct. 2, 2006, at the Electromagnetic Test Facility, courtesy of the Naval Surface Warfare Center Dahlgren Division (NSWCDD) Laboratory.





EM Railgun Snapshot

- Minimizes susceptibility to GPS jamming and simplifies deconfliction
- Direct fire horizon in 6 seconds
- Hypervelocity electromagnetic launch (Mach 7.5)
- Hypervelocity impact (Mach 5) indirect fire (200+ nautical miles in 6 minutes)
- Fixed and relocatable targets at long range
- GPS guidance, navigation and control
- Ballistic trajectory; large capacity magazines; no propellants
- No explosive warheads;reduced ship vulnerability; simplified logistics
- Long-range; time-critical; persistent; all-weather (24/7)
- No unexploded ordnance issues and support for distributed operations

The Army began research in 1985 to develop a mobile, ground-based electromagnetic system capable of defeating future armored combat vehicles.

It is the refurbished SDI launcher that is currently installed at NSWC Dahlgren, while the program awaits delivery in June 2007 of a gun being built by BAE Systems. The new gun is a "laboratory" version with removable rails that weighs in at 40 tons, according to Garnett.

As Dr. D'Andrea noted, it is the combination of three technology "enablers" that sets the stage for developing a long-range naval railgun. The first stems from the Secretary of the Navy decision to make the next Navy surface combatant, DDG-1000, an Integrated Power System (IPS) ship.

This decision opened the door for a new generation of "electric" weapons, including railguns.

With proper design, the IPS can dedicate most of the power to electric propulsion motors for high-speed operations or when the tactical situation allows, the power can be shared among various electric weapons and sensors.

The amount of power required for a railgun depends on the rate of fire. With an expected 80 megawatts of installed electrical power, electric warships will have ample power to supply a railgun with the 15-30 MW necessary for sustained fires at 6-12 rounds per minute.

It's worth noting that the railgun would eliminate the need for both gun powder and explosives from the magazine. This improves ship safety and lowers logistics costs.

The second enabler is the advance in precision-guided projectile technology, evidenced by the success of programs such as Barrage, Extended Range Guided Munition (ERGM) and the Autonomous Naval Support Round (ANSR). The proliferation of Guidance, Navigation and Control (GNC) systems for Defense Department applications suggests opportunities for smaller, more robust packages at reduced cost.

These trends can only benefit the development of an affordable, hypersonic, guided projectile for railguns.

Finally, the result of Army-sponsored research at the University of Texas Institute for Advanced Technology has provided significant progress in the area of barrel life. Solutions defined at small scale in the university environment will be tested at large scale at the Dahlgren Electromagnetic Launch Facility.

Future Plans

For the ONR-sponsored program at NSWC Dahlgren, the build to a fully operational facility will be conducted in steps. The low-energy initial shot will lead to gradual increases in energy and speed that will lay the groundwork for the engineering team with data, analysis and hands-on experience in preparation for the delivery of the 32 MJ gun expected in summer 2007.

In parallel, the program will be increasing its pulse power capabilities to power the higher energy launcher.

The envisioned tactical Navy system of 64 MJ of muzzle energy is one step closer to fruition with the stand up of the Navy's largest operational EM facility. The engineers at Dahlgren, under the sponsorship of the ONR Electromagnetic Railgun Program will continue to exploit the recent advances in science and technology that made this technology feasible.

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CHIPS

– Fact Sheet from Program Executive Office, Ships

DD(X) 1000

The Navy's first DD(X) destroyer featuring an Integrated Power System (IPS) will be designated DDG 1000. As the lead ship in the class, it will be named in honor of former Chief of Naval Operations Adm. Elmo R. "Bud" Zumwalt Jr.

Zumwalt is the lead ship in a class of next-generation, multimission surface combatants tailored for land attack and littoral dominance, with capabilities designed to defeat current and projected threats as well as improve battle force defense.

Compared to current U.S. Navy destroyers, the Zumwalt-class destroyer will triple both current naval surface fire coverage, as well as capability against anti-ship cruise missiles. It has a 50-fold radar cross section reduction compared to current destroyers, improves strike group defense 10-fold and has 10 times the operating area in shallow water regions against mines. The Zumwalt class fills an immediate and critical naval warfare gap, meeting validated Marine Corps fire support requirements.

The IPS technology includes an advanced gun system, an advanced peripheral vertical launch system, integrated undersea warfare automation for mine avoidance, dual-band radar, at-sea weapons effect and an autonomic fire suppression system and the Total Ship Computing Environment.

Under the Navy's dual lead ship acquisition strategy proposed in the President's budget for fiscal year 2007, Northrop Grumman Ship Systems and General Dynamics Bath Iron Works will concurrently build the dual lead ships. Zumwalt will be delivered in 2012.